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AUTHOR Micheli, Gene S.: And Others
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ABSTRACT

This report discusses developments in computer based instruction (CBI) and presents initiatives for the improvement of Navy instructional management in the 1985 to 1995 time frame. The state of the art in instructional management and delivery is assessed, projections for the capabilities for instructional management and delivery systems during this 10-year period are established, and viable alternatives to the current Navy computer managed instruction system are identified. The major categories of current CBI systems are examined in the context of their problems and capabilities, current and future trends in CBI systems are presented and an economic assessment of Navy needs is provided, which includes projected technological capabilities in hardware, software, and courseware to satisfy those needs. Functional components of CBI are identified and analyzed with an assessent of these alternatives in terms of key system characteristics. Finally, recommendations are provided for actions to be taken in support of CBI system development. Appendices list the consultants to this study and the major categories, subcategories, and functions of CBI.
(Author/MER)

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COMPUTER BASED INSTRUCTIONAL SYSTEMS--1985 to 1995

Gene S. Micheli
Charles L. Morris
William M. Swope

Training Analysis and Evaluation Group

August 1980

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Alfred F. Smode

ALFRED F. SMODE, Ph.D., Director,
Training Analysis and Evaluation Group

Worth Scanland

WORTH SCANLAND, Ph.D.
Assistant Chief of Staff for
Research and Instructional Systems
Development
Chief of Naval Education and Training

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This report discusses developments in computer based instruction (CBI) and presents initiatives for the improvement of Navy instructional management in the 1985 to 1995 time frame. It describes the major categories of CBI, discusses trends in CBI, and provides an economic projection of CBI developments. Four CBI alternatives are presented along with an assessment of these alternatives in terms of key system characteristics. Recommendations are provided for actions to be taken in support of 1985 to 1995 CBI system development.

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TABLE OF CONTENTS

Section		Page
I	INTRODUCTION	3
	Purpose of the Study	4
	Approach	4
	Organization of This Report	5
II	CATEGORIES, TRENDS, AND ECONOMIC ASSESSMENT OF COMPUTER BASED INSTRUCTION	7
	Major Categories of CBI	7
	Trends	10
	Economic Assessment of CBI	11
III	INSTRUCTIONAL MANAGEMENT SYSTEMS	19
	Instructional Management System Model	19
	CBIM System Hardware and Software Architecture	23
	State-of-the-Art CBIM Systems	25
	CBIM Trends	25
IV	INSTRUCTIONAL DELIVERY SYSTEMS	27
	Categories of Instructional Media	28
	State-of-the-Art of Instructional Delivery Systems	28
	Trends	36
V	INSTRUCTIONAL MANAGEMENT ALTERNATIVES	39
VI	RECOMMENDATIONS IN SUPPORT OF 1985 TO 1995 CBI SYSTEM DEVELOPMENT	43
REFERENCES		45
APPENDIX A	Consultants Contributing to This Study	47
APPENDIX B	Major Categories, Subcategories and Functions of CBI	53

LIST OF ILLUSTRATIONS

Figure		Page
1	Major Categories of CBI	8
2	Major Subcategories of CBI	9
3	Index of Trend in Processing Speed Between 1970 and 1990	13
4	Projected Average Costs of Microcomputer Chips (1970 to 1990)	14
5	Index of Trend in Memory Costs Between 1970 and 1990	15
6	Index of Trend in Average Processing Costs Between 1970 and 1990	16
7	General Management Model	20
8	Instructional Management Model	21

LIST OF TABLES

Table		Page
1	Military CMI Systems	4
2	Categories of Instructional Media (After Braby)	29
3	Categories of Instructional Media (After Logan)	29
4	Categories of Army Instructional Media	30
5	Summary of Findings on CAI and CMI, Compared to Conventional Instruction	33
6	Computer-Aided Instructional Programs Planned/In Place In Navy Training	34
7	Instructional Management Alternatives	40
8	Characteristics of Alternatives	42

SECTION I

INTRODUCTION

This report discusses developments in computer based instruction (CBI) and presents initiatives for the improvement of Navy instructional management in the 1985 to 1995 time frame. During the past decade computer based instruction has been widely applied in the U.S. Navy. The Navy's Computer Managed Instruction (CMI) System, which became operational in 1973, provides a means for guiding students through a curriculum of instruction. It presently serves 14 schools at five geographic locations. The approximate student average on board (AOB) and throughput for CMI courses in FY 78 were 7,000 and 65,000, respectively. A plan exists to expand this system to 25 schools and an AOB of 16,000 students at six locations. Computer managed instruction is the largest component of CBI in the Naval Education and Training Command (Zajkowski, Heidt, Corey, Mew, and Micheli, 1979).

The use of computers in the management of instruction also has been instrumental in enhancing the Navy's capability for the delivery of individualized instructions. In fact, the extent to which instruction has been individualized "... would have been impossible for the number of students we are dealing with were it not for the availability of CMI.... It gives a partial answer to the restraints the Congress is placing upon us for reductions in the costs of training and the size of training staffs" (Scanland, 1975).

All the military services intend to increase their use of CMI. Table 1 shows the projections for military CMI systems planned for the early 1980s (Van Matre, 1979).

TABLE 1. MILITARY CMI SYSTEMS

	NAVY CMI	AIR FORCE AIS	ARMY CTS	ARMY AIMS	MARINE CORPS CBE
Students Daily	16,000	2,400	365	1,600	2,000
Courses/Schools	25	4	4	2	4-8 CAI 40 + CMI
Locations	6	1	1	22	1

Source: Van Matre (1979)

At the November 1979 meeting of the Chief of Naval Education and Training (CNET) Experimental Training Programs Policy Board it was pointed out that due to technological advances, the current Navy CMI system will become outdated in the 1985 to 1995 time frame. The CNET tasked the Training Analysis and Evaluation Group (TAEG) to conduct a study of the current and projected state-of-the-art in the technology associated with the management and/or delivery of instruction as a basis for developing initiatives for the future.[1]

PURPOSE OF THE STUDY

The present study (1) assesses the state-of-the-art in instructional management and instructional delivery, (2) establishes projections of the capabilities for instructional management and instructional delivery systems during the 1985 to 1995 time frame, and (3) identifies viable alternatives to the current Navy CMI system.

APPROACH

There were five major components to the approach used in this study. First, an analysis was made of current Navy CBI systems in terms of capabilities and problems. Second, literature dealing with current and future trends of instructional management and delivery was reviewed. Third, visits were

[1]CNET ltr Code N-5 of 19 Nov 1979

made to acknowledged experts (listed in appendix A) for discussion and assessment of Navy needs and projected technological capabilities in hardware, software, and courseware to satisfy these needs. Fourth, functional components of computer based instructional management systems were identified and analyzed in order to arrive at the functions of an ideal instructional management system. Finally, alternative systems capable of providing the functions were identified and assessed for implementation constraints which would impact on operational use during the 1985 to 1995 time frame.

ORGANIZATION OF THIS REPORT

In addition to this introductory section, this report contains five sections and two appendices. Section II describes the major categories of CBI, discusses trends in CBI, and provides an economic projection of CBI developments. Section III provides a discussion of instructional management systems. Section IV provides the state-of-the-art and trends of instructional delivery systems. Section V presents four CBI alternatives and contains an assessment of these alternatives in terms of key system characteristics. Section VI provides recommendations for actions to be taken in support of 1985 to 1995 CBI system development. Appendix A lists the consultants contacted during this study. Appendix B describes the major categories, subcategories, and functions of CBI.

SECTION II

CATEGORIES, TRENDS, AND ECONOMIC ASSESSMENT OF COMPUTER BASED INSTRUCTION

This section (1) identifies and defines the major categories of CBI to be analyzed in the remainder of the report, (2) discusses trends in CBI, and (3) provides economic projections of CBI developments. Computer based instruction is a generic term used to describe any instructional system in which computer capabilities are utilized to manage, deliver or support instruction, or to maintain administrative information on instructional processes. This definition does not provide sufficient specificity for detailed comparative analyses of various systems. However, a general industry acceptance of two categories of CBI has evolved, computer assisted/aided instruction (CAI) and computer managed instruction (CMI). The former is involved in the delivery of instruction, while the latter, in general, simply manages a program of instruction without a delivery component. Even though these functions are distinctly different, the fact that they can be employed together in a single system has given rise to some confusion in terms. Therefore, an attempt is made in this report to provide a framework for understanding and differentiating between categories of CBI.

MAJOR CATEGORIES OF CBI

Major categories of CBI to be addressed in this study are shown in figure 1. Computer based instructional management (CBIM) includes those functions which manage or guide a student through an instructional sequence such as testing, response analysis, prescriptive guidance, and student monitoring. Computer based instructional administration (CBIA) includes all of the record keeping and reporting required for effective program administration. Computer based instruction support (CBIS) includes instructional/learning resource management and allocation, program development coordination, configuration management, and computer support functions. The functions included in each of these major CBI subcategories are shown in figure 2. They are also described in greater detail in appendix B.

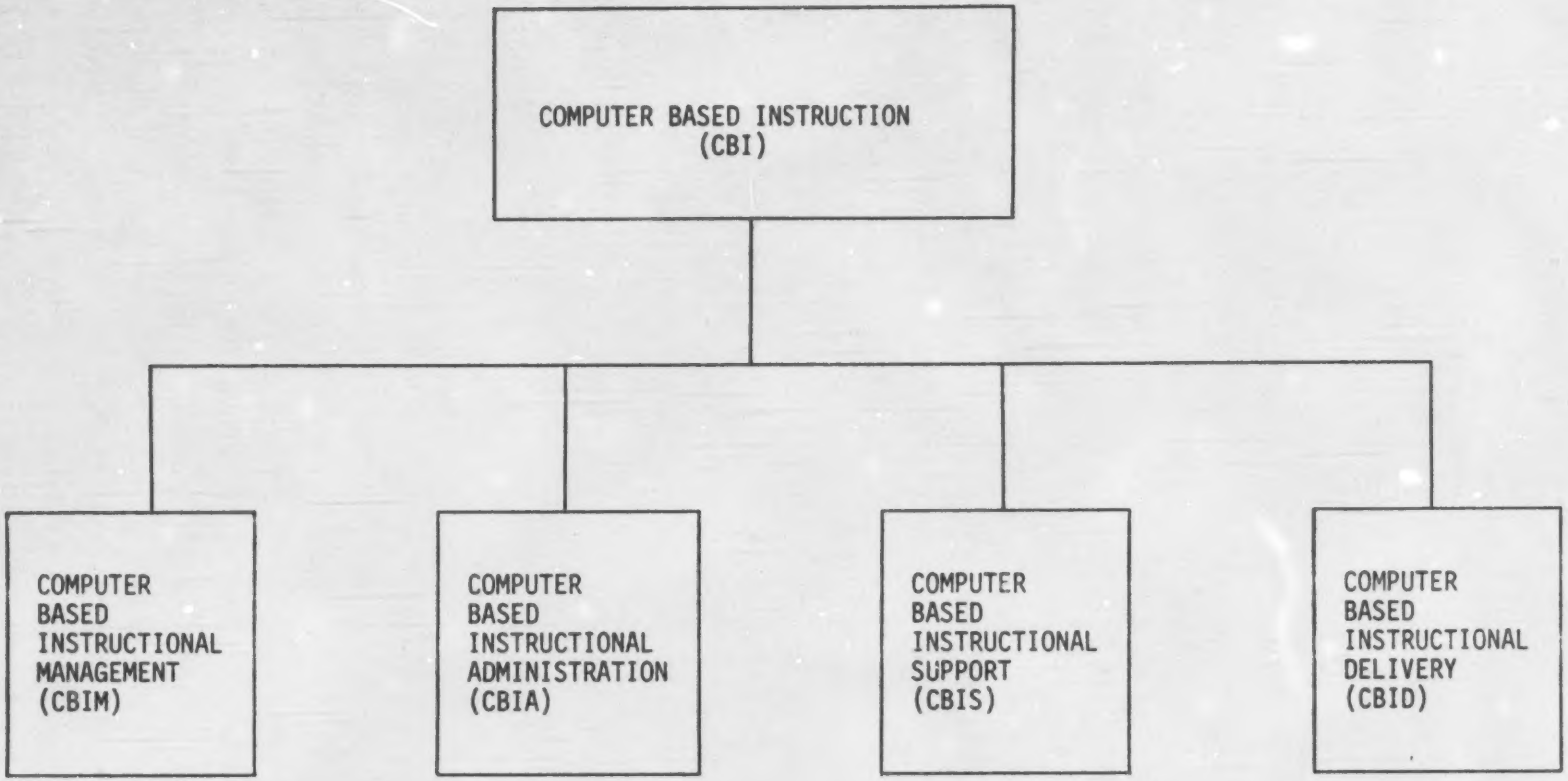
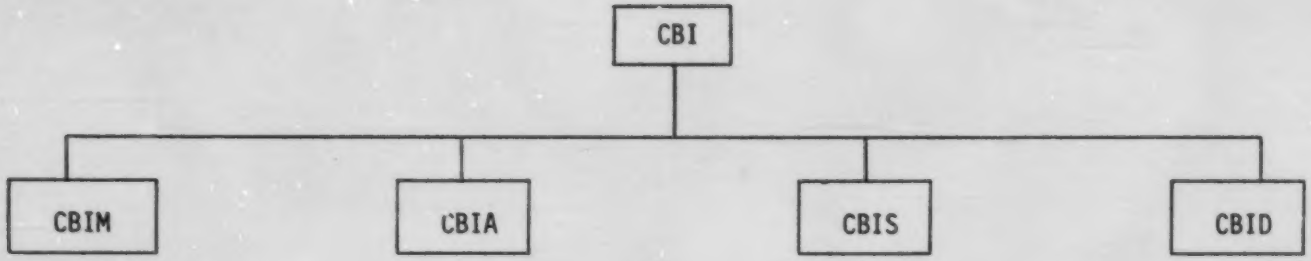


Figure 1. Major Categories of CBI



- STUDENT SCHEDULING/ SEQUENCING
- MODULE-LESSON DATA BANK
- TESTING

- MANAGEMENT AND ADMINISTRATION
- REPORT GENERATION

- TRAINING RESOURCE MANAGEMENT
- INSTRUCTIONAL PROGRAM DEVELOPMENT COORDINATION
- CONFIGURATION MANAGEMENT
- COMPUTER SUPPORT

- CONVENTIONAL CAI
- COMPUTER SIMULATION
- COMPUTER CONTROLLED VIDEO
- COMPUTER GRAPHICS

Figure 2. Major Subcategories of CBI

Computer based instructional delivery (CBID) is a unique category which includes all computer based media options. These options would include classical CAI, computer graphics, computer controlled video, computer simulation, and computer based training devices. Computer based instructional delivery together with CBIM has almost unlimited potential for development and growth and will therefore be the areas in which Navy instruction will make its greatest advances. However, it should be recognized that the administration and support categories of CBI (CBIA and CBIS) will be essential for the orderly and cost-effective implementation of large scale CBI systems.

TRENDS

During the next decade computer developments which support instructional processes are likely to evolve to the extent that all functions which can be computerized will be. Therefore, a key decision at this time involves the choice between a system configuration which would result from evolutionary growth of existing systems and a large scale integrated system developed under an RDT&E program in terms of maximum effectiveness/efficiency in the 1985-1995 time frame. However, a general consensus seems to be that whatever general system is selected the underlying general development strategy should include the central management of system and network standards with autonomous decentralized processing and data base control. This general strategy permits a wide range of local hardware/software options for CBI while requiring strict adherence to central management policy relating to network configuration, data base management, communications protocol, and configuration management.

A number of initiatives will be required to implement this approach among which will be the phasing out of the existing Navy CMI System and a phasing in of a new CBI system with greatly expanded capability. A major contributing factor to this situation is an increasing trend toward the use of unique computer training applications arising out of special training requirements such as electronic warfare training and nuclear power training. Since it is relatively certain that this trend will continue, the instructional management network of the future must allow for inclusion of these unique applications within a global management structure. This can only be

accomplished through centrally controlled policy development and the establishment of explicit standards for computer based instructional network membership.

Computer technology has developed to such a point that computer hardware cost has become a secondary consideration to computer software cost. The following paragraphs address the underlying economic considerations which have brought about this change.

ECONOMIC ASSESSMENT OF CBI

The feasibility of adopting new improvements in computer technology for computer based training applications depends upon both technical effectiveness and economic efficiency. The technical effectiveness, along with some insights into the future course of developments in instructional technology, is addressed elsewhere in this report. New and improved computer technology which will support effective training is a necessary but not sufficient condition for adopting this new technology for Naval training. The adoption of any improved technology must also be economically efficient; i.e., it must also provide the most economic means of reaching the training objectives if it is to be rationally integrated into the Navy training system. Economic analysis is an analytical procedure for determining the cost-effectiveness of alternatives for satisfying training objectives.

As previously mentioned, this study focuses on the anticipated state of computer technology as it will exist for the period 1985-1995 and is designed to provide policy guidance as to the appropriate planning decisions which will enable the Navy to plan for the most cost-effective, long-range training system. Since the study does not address any specific training system alternatives, it is inappropriate to provide an economic analysis supporting or recommending a specific long-range plan for either accepting or rejecting projected computer technology. Specific recommendations will depend on the new (and as yet undefined) hardware systems, software requirements, future training requirements, existing resource configurations, and relative resource prices.

TRENDS IN COMPUTER PROCESSING COSTS. One of the most important considerations in determining the economic desirability of adopting new and improved computer technology is the relative productivity per dollar spent on both the old and new system. Any training task can be accomplished with an almost infinite set of resource combinations. Which set is the most economically efficient is determined by both factor productivity and factor cost. Any disproportionate change in either productivity or cost will ultimately require a change in the relative ratios with which the resources are used in training. Often changes in productivity and costs are brought about by technological advances. In computer technology there has been a substantial increase in productivity and both total cost of hardware and average processing costs have dropped precipitously. These changes make it imperative that the training system be reconfigured in the long run to more fully utilize and capture the efficiencies of the new computer technology.

The trend in productivity for hardware has shown phenomenal improvement over the last several years. Most experts believe that this rate of improvement will continue through 1990. If such improvements do continue, then processing speed in 1990 is expected to be approximately 200 times faster than that which existed in 1970. This trend is illustrated in figure 3.

The processing speed and anticipated reduction in real costs of microprocessing components will contribute significantly to more cost-effective computational facilities. Trends in costs of microprocessor chips are illustrated in figure 4. It is expected that the cost of a 16 bit microprocessor chip will cost less than $10 by 1990. The cost of a 4 bit microprocessor chip will be less than $1.

The cost of memory is also going down. If present trends continue, as they are expected to do, the 1990 memory costs per bit will be less than 1 percent of the 1970 costs. This trend is illustrated in figure 5. The net result of improvements in microprocessor costs, processing speed, and memory costs has resulted in an extremely rapid decline in average storage and processing costs. Projections through 1990 indicate that the average processing costs will be less than 1 percent of the 1970 processing costs as illustrated in figure 6.

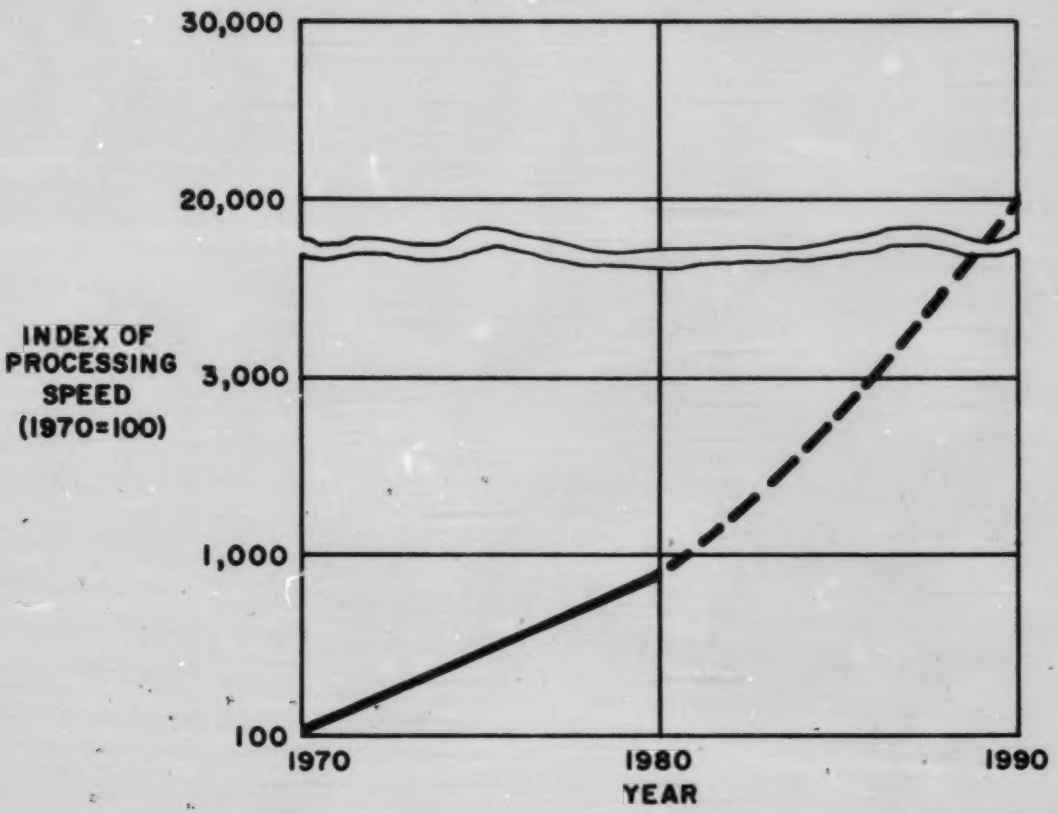


Figure 3. Index of Trend in Processing Speed Between 1970 - 1990 (1970 = 100)

Source: Adapted from Office of Technology Assessment (1979)

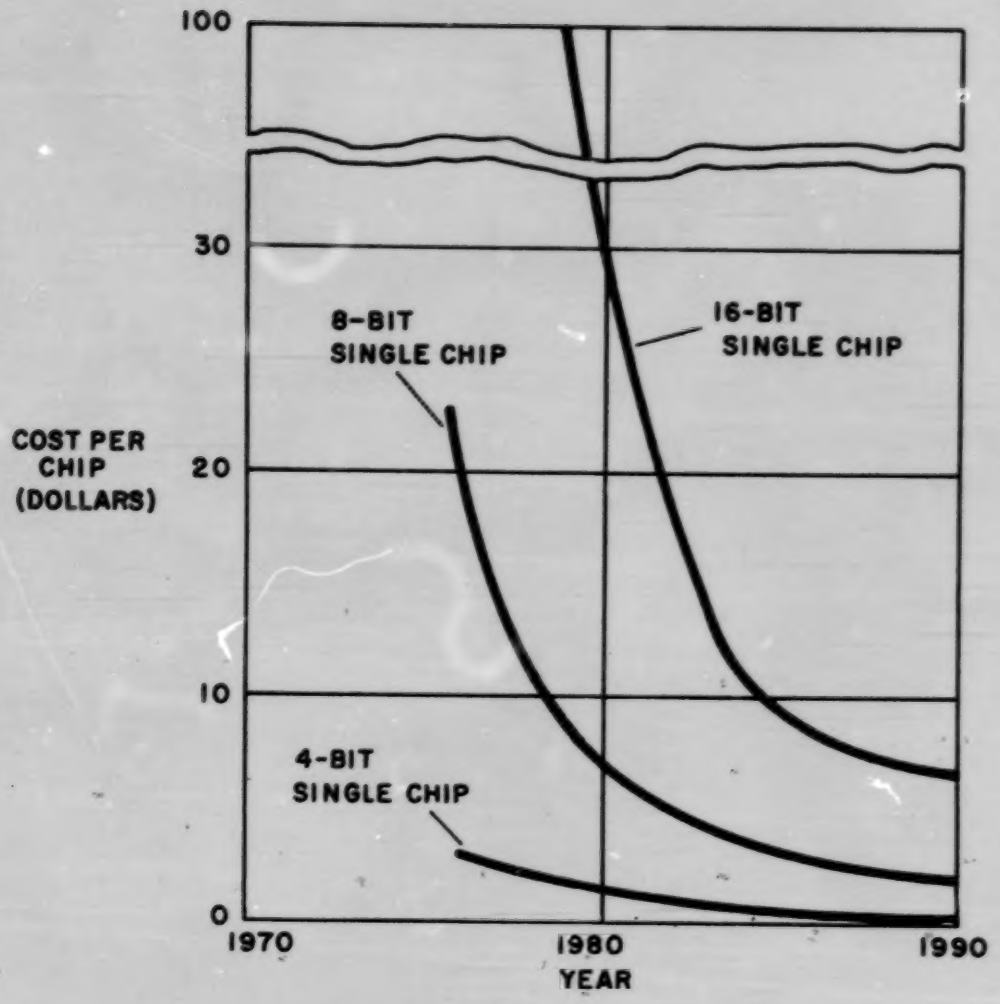


Figure 4. Projected Average Costs of Microcomputer Chips (1970 - 1990)

Source: Motorola Semiconductor Group (1980)

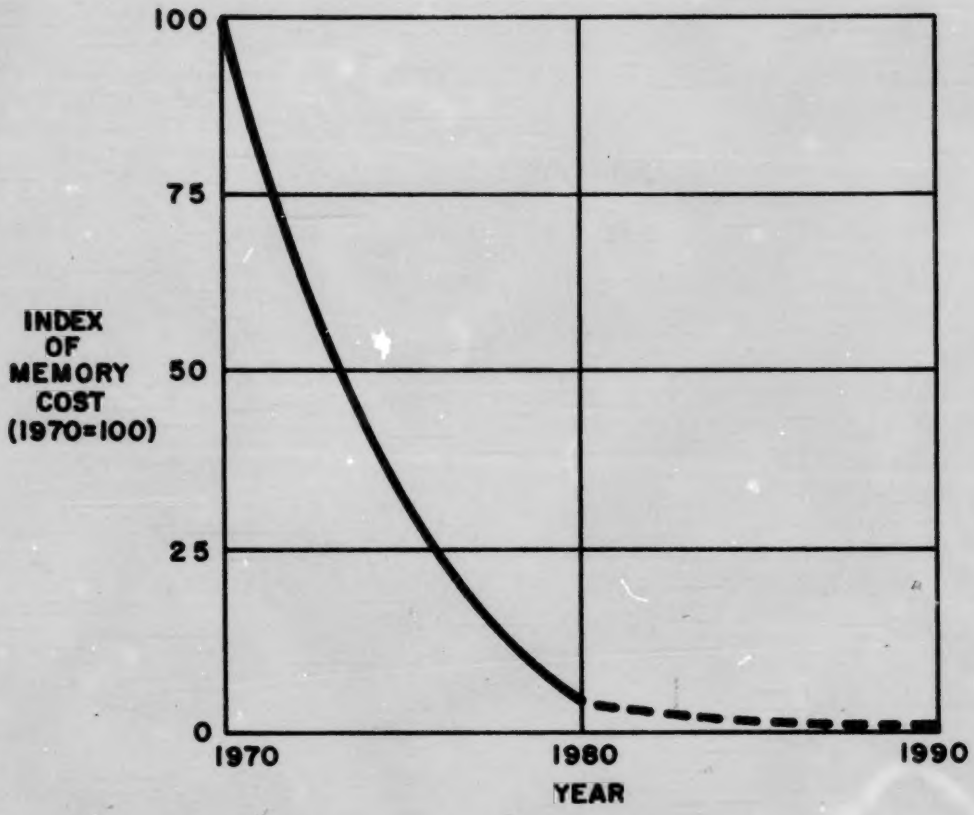


Figure 5. Index of Trend in Memory Costs Between 1970 - 1990

Source: Adapted from Noyce (1977)

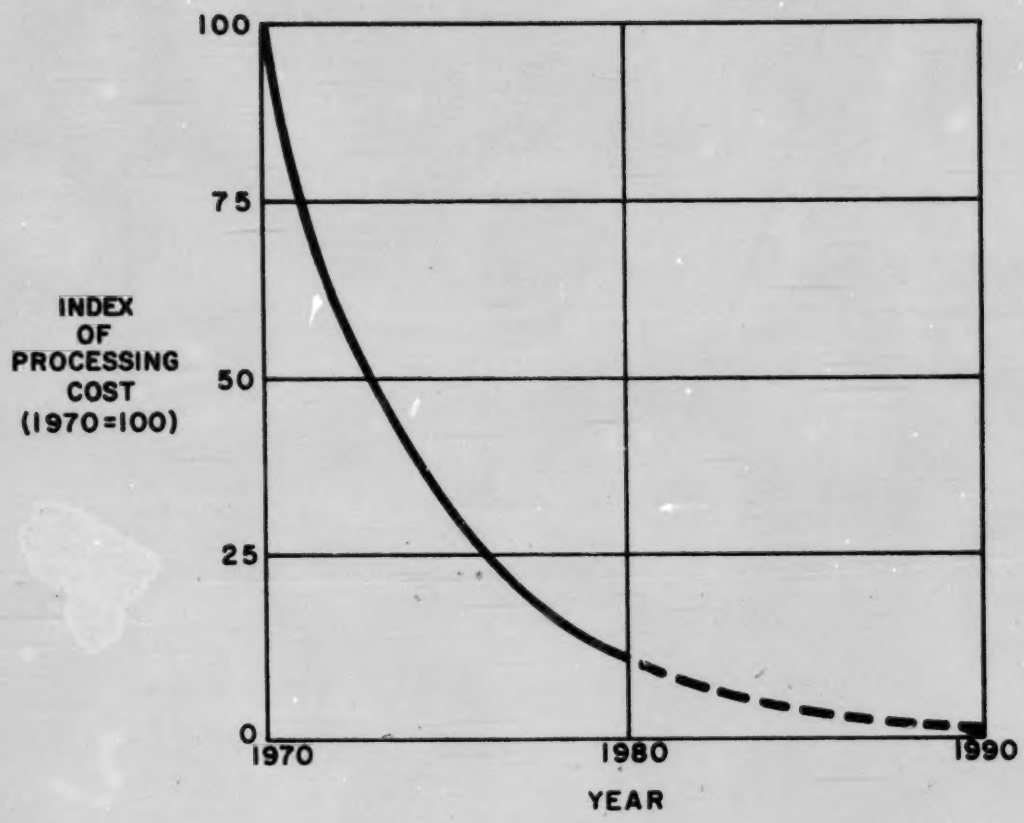


Figure 6. Index of Trend in Average Processing Costs Between 1970 - 1990

Source: Adapted from Office of Technology Assessment (1979)

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During the same period (in which the productivity of computer technology was increasing and costs were dropping), the average labor costs in training have been increasing. This change in relative price ratios shifts the economic advantage to those alternative training systems which utilize computers to substitute for the relatively expensive labor.

SCALE ECONOMIES. Scale economies occur when average training costs decrease with increases in the number of students trained or size of the training systems. These economies can be attributed, in part, to the opportunity to use capital which is highly efficient. Until recently, it was necessary to use large computer hardware systems in order to obtain the computational capacity and speed necessary for training systems. It has simply not been economically feasible to develop a computerized training system for many of the smaller training systems. Courses and/or training systems with large throughput were the only ones which could obtain the necessary efficiencies to justify a computerized training system. The new developments in computer technology have changed the cost functions in such a way that it will no longer be necessary to have a large throughput in order to capture the scale economies. The importance of scale of operations or the size of the training systems is becoming less of an issue in the cost effective calculation.

SOFTWARE DEVELOPMENT. The rapid increase in the technical capability of the hardware has provided the opportunity to use the computer for more sophisticated and widespread applications. However, these uses often require the development of unique software packages. Software development is extremely labor-intensive and, therefore, very costly. The increased use of hardware will require greater commitment of resources to software development, and in the long run software costs will be the dominant cost factor in the selection of a computerized training system. This increased cost can be attributed to the volume of software which must be developed and not to inefficiencies in the development of software.

The total software development costs depend on the quantity of software which must be developed as well as the efficiency in developing software. The increased software costs projected for the future result from the fact

that with widespread use of hardware there will be a greater quantity of software required for the additional systems. Tending to offset this increase in the cost of providing more software will be a decline in the average cost of developing the new software packages. This decline in average cost will be due to the development of more sophisticated high level programming languages. These programming languages will be highly user-oriented and will reduce labor requirements for developing specialized applications programs. The total costs of developing and maintaining the high level programming languages will be high, but these costs can be amortized over a large number of applications which will tend to drive down the average cost.

Almost every potential application of computer technology within the Navy will involve changes in training programs. The extent of changes which are economically efficient is one fundamental question which an economic analysis must answer. A rational analysis would involve a study of each component of the existing training program to determine which component or module can be efficiently computerized. Since we seldom start from "ground zero," there is a need to evaluate the existing capital resource base and determine the most efficient means of integrating the new computer technology into the existing system. The total replacement of sunk capital will seldom be economically efficient, especially in the short run. However, in the long run it may very well be more efficient to plan for total replacement. Each problem requires a specific analysis, and that analysis must be based on an incremental approach.

The efficiency of each candidate system in meeting the various management and delivery functions will undoubtedly differ. It would be unusual to find a single computerized system which would be most efficient in carrying out all management and delivery functions. The computer system ultimately selected for each application must be one which results from a melding of the various performance requirements with the most cost-effective computer system for performing the composite of those functions.

SECTION III

INSTRUCTIONAL MANAGEMENT SYSTEMS

INSTRUCTIONAL MANAGEMENT SYSTEM MODEL

A general model is presented here relating general management functions to instructional management functions. It shows that the instructional management process is not unique, and it is suggested that established management techniques, when properly applied to instruction, can result in greater management efficiency.

In spite of the fact that state-of-the-art instructional management systems are structured in a variety of ways, they nevertheless exhibit common management characteristics. These characteristics include planning, organizing, command/executing, coordinating, and controlling (George, 1972). A general management model with these functional elements is represented diagrammatically with the addition of an evaluation function and feedback loop in figure 7. Without a feedback path, the system would operate "open loop" and the output product could deviate significantly from plan.

With this general model, it is possible to relate general management to instructional management. This relationship is presented diagrammatically in figure 8. For the instructional management case, the task becomes one of managing a training system in which the learning process consists of developing skills, knowledges, and attitudes. Entry testing provides a student input measure; progress testing allows for progress evaluation and prescriptive guidance during the learning process; and output testing certifies that training objectives have been satisfied. This model can be used to compare specific types of instructional management systems described in subsequent paragraphs in terms of the degree and efficiency with which they are capable of accomplishing the identified function. It is, however, not meant to be a comprehensive model of the instructional management process.

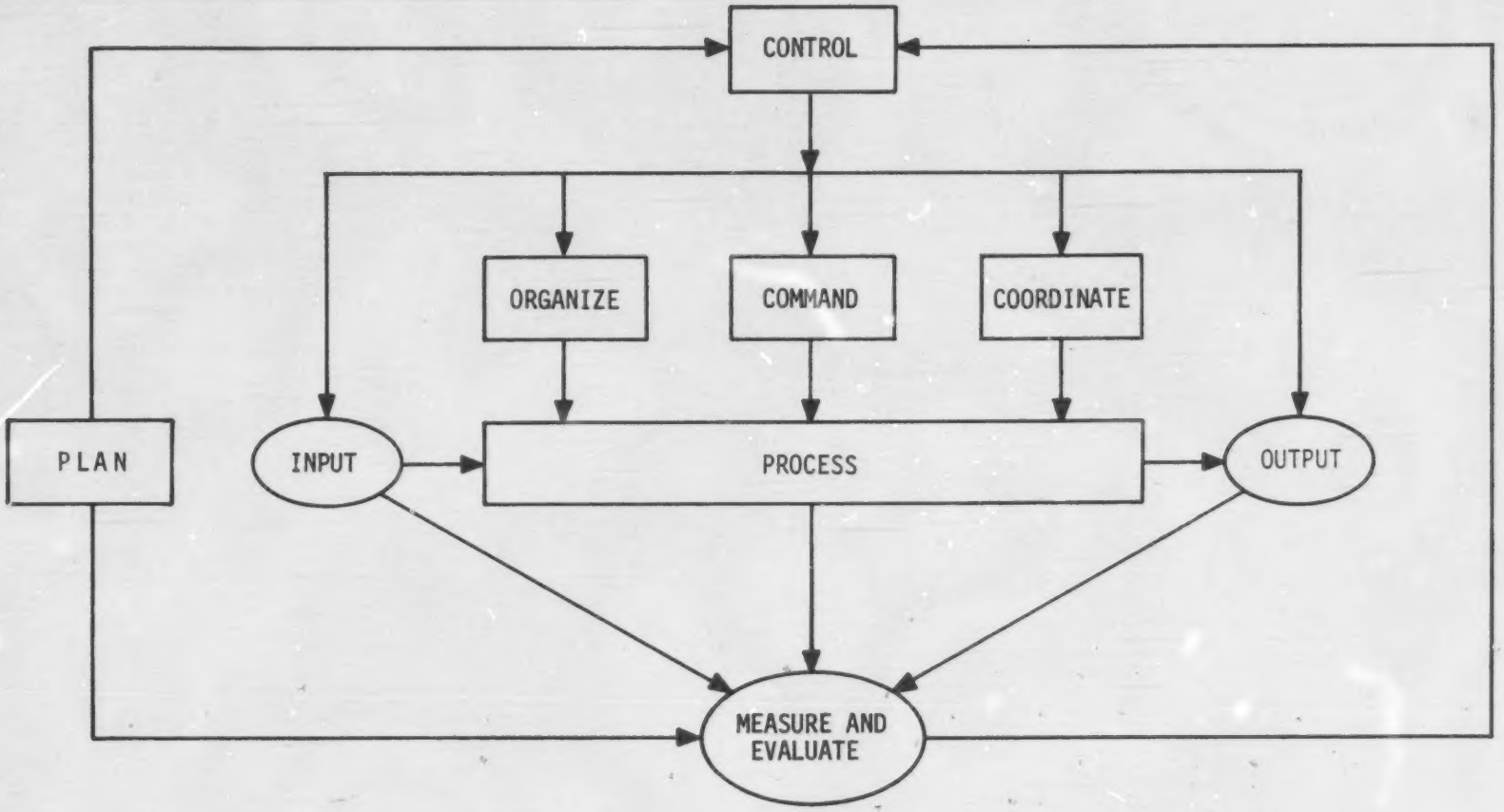

Figure 7. General Management Model

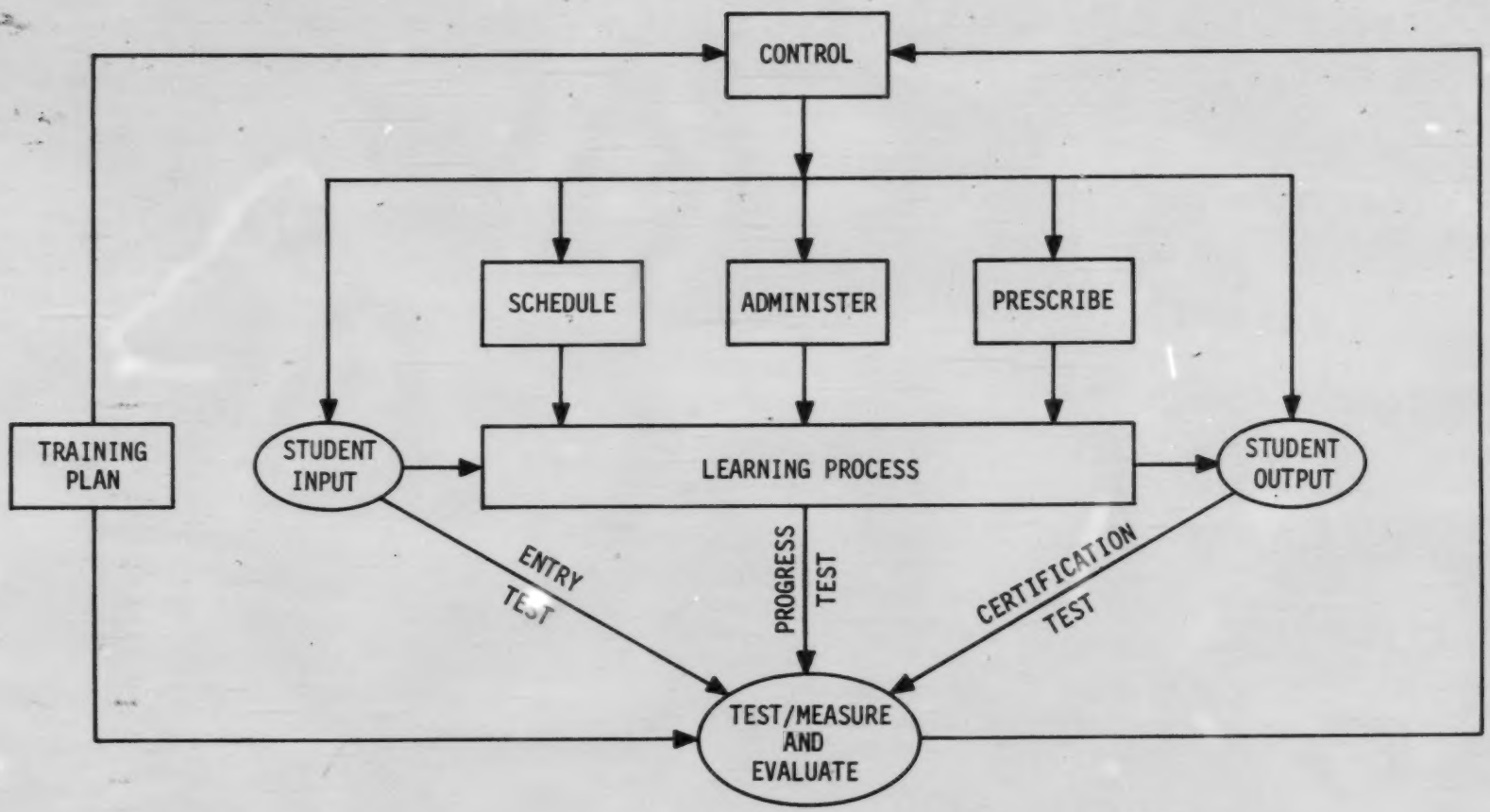

Figure 8. Instructional Management Model

Most current instructional management systems can be categorized as instructor-based instructional management or computer-based instructional management. The instructor-based case relates to traditional methods of instructional management without benefit of computer support. The computer-based case relates to computer-supported instructional management and administrative data handling processes. The distinctions between these two generic categories are blurred by many possible types of application of the computer in the instructional process. For example, an instructor-managed system in which student training and administrative data are stored in and processed by a computer might be termed a form of computer-based management. However, in this study, the term computer-based instructional management is restricted to computer management of instructional processes and not to computerized administrative, support, or delivery processes. The primary reason for this differentiation is that many existing CMI systems provide administrative information processing and direct computer-based delivery of instruction. These systems would properly fall within the category of computer-based instructional systems but not totally within the subcategory of computer-based instructional management systems.

In this study, the concept of computer-based instructional management will apply to a range of computer supported functions. The minimal case is the use of a computer for test scoring. This would be similar to the instructor-based management case with the single exception of computerized test scoring. At the opposite end of the computer-based instructional management spectrum would be the hypothetical "training factory" (Baker 1978) in which all training management functions are computerized. In assessing the dozen or more instructional management systems which are currently available, or any other alternative which might be designed, several key issues must be addressed to insure successful implementation: (1) Are they applicable in all training situations? (2) Are they now or are they projected to be economically efficient/effective? (3) Are they operationally and logistically supportable over their life cycle? (4) To what extent are they subject to technological or functional obsolescence? (5) Do they have top management support? (6) Is the user community committed to the implementation and maintenance of the system? (7) Is funding support assured for the life cycle of the system? Technological

considerations, which are well within the state-of-the-art, do not appear to be a constraining factor for the 1980 to 1995 time frame.

CBIM SYSTEM HARDWARE AND SOFTWARE ARCHITECTURE

Traditionally, computer-based instructional systems have consisted of one or more central processors communicating with a number of time-sharing terminals. This arrangement provides an interactive input-output capability which has been applied for instructional management, instructional delivery, and administrative data handling functions. For the typical case, this arrangement is still considered to be a relatively direct and effective means of satisfying computer-based instructional system requirements. However, as the application of computer-based instructional technology becomes more widespread and as computer network architecture technology and capabilities evolve, additional longer range considerations become apparent. It should first be determined if the application of computer-based instructional technology in Navy training is likely to increase during the long-range planning period and, if so, at what rate. The results of this determination should then be used to project the sequencing of integrating CBI functions into existing training systems. When this instructional technology need/capability/implementation projection has been completed, system architectural alternatives can be developed. For the case of Navy training, it is envisioned that the development and implementation of a Navy-wide computer-based instructional management system would be more extensive than any computer-based training application currently in use. Based upon an analysis of state-of-the-art systems, the following system characteristics have been identified as development guidelines:

1. System hardware architecture should not reduce procurement options to a single supplier for processing, storage, or communications components.

2. Software architectural design should follow state-of-the-art thinking in relation to user oriented high level language development, structured programming, program modularization, custom operating systems, documentation relevancy, and system wide software compatibility.

3. Distributed network architecture should provide a data base design which allows global network data access only where required. Local data base control should be the general rule wherever practicable. In addition, standards for communication protocol, data handling software, message formats, and data base management should be developed to preclude a dependence on single supplier systems. It is highly probable that computer-based instructional management systems will eventually interface with large numbers of unique processors (intelligent terminals, special training devices, CAI systems, video graphic terminals, and videodisc controllers). System communications standards will be essential if interface compatibility is to be achieved.

4. Computer software management systems together with effective configuration control systems are essential for any large scale computer-based development. Department of Defense (DOD) software management systems have been evolving for a number of years and are now reasonably effective although costly to implement and maintain. Because these systems are, in essence, management control systems, they should be carefully evaluated in terms of their ability to maintain currency in an environment of continuous change. Since a computer-based system of this type becomes a management tool, it is important that control be exercised by training program management.

In assessing current state-of-the-art systems, it appears that the issue again becomes one of implementation considerations. The hardware and software are available today to mechanize/automate almost any training function envisioned. Computer cost is decreasing and manpower cost is increasing, both at rates which are likely to bring about wide application of computer-based training during the next decade. Consequently, it will be necessary to provide the needed planning and operational support to assure operational effectiveness in the desired time frame.

STATE-OF-THE-ART CBIM SYSTEMS

The application of CBIM, often referred to as computer managed instruction (CMI), has grown steadily during the past decade. Ten private and public sector applications were identified and analyzed in 1974 (Middleton, Papetti, and Micheli, 1974). Although growth in the number of systems has not increased significantly since then, student loading has continued to increase and system characteristics have continued to evolve. The Navy training CMI system is an example of a large-scale centralized (nationwide central processing) system which was well conceived and which continues to perform effectively. The Air Force Advanced Instructional System (AIS) is an example of a decentralized (base level autonomous operation) system, which like the Versatile Training System (VTS), the Aviation Training Support System (ATSS), and the Army Automated Instructional Management System (AIMS), appears to have many of the necessary CBIM characteristics. However, training center or school-based systems such as these require extensive instructional program development, computer programming, and configuration management support. These support requirements, combined with significant front-end investment, have caused some extension in the implementation schedules of the above systems. The long-term payoff still appears on the horizon, but short-run expansion schedules are not expected to meet original goals.

State-of-the-art military CMI systems have been well described in a number of studies (Orlansky and String, 1979; Zajkowski, et al., 1979; Middleton, et al., 1974) and therefore are not described in detail in this report.

CBIM TRENDS

During the course of this study, many valuable concepts relating to future computer applications in instructional management were offered by experts in the field.[1] This expert opinion and the examination of related

[1]Since the primary intent of this study was to forecast developments in computer based instruction, emphasis was placed on discussions with experts in this field. They are named in appendix A.

research led to the development of two major conclusions. These conclusions are presented below with supporting rationale.

1. There is a high probability that the use of CBIM will increase significantly during the 1985 to 1995 time frame. The trends identified which support this position are:

a. decreasing computer system hardware costs
b. increased software development efficiency
c. increased capability of applications software
d. wider user acceptance of computer-based applications.

2. During the 1985 to 1995 time frame, CBIM will become decentralized and highly autonomous. However, strict adherence to central management policy and network standards will be essential for a global computer intercommunications capability which appears to be a necessary goal for system management and control. The trends identified which support this conclusion are:

a. Small, powerful computer systems will be available at low cost for remote stand-alone operation.

b. Reliability, maintainability, supportability, and versatility figures of merit for stand-alone computer systems continue to improve.

c. New network architectures which allow for distributed data base management, remote processing, and central network control are continuing to evolve.

d. A strong trend toward stand-alone CBID, as evidenced by current CAI and device based training applications, will bring about a requirement for interfacing these delivery systems with instructional management systems. This can be accomplished most easily with a highly decentralized CBIM capability under control of a global network manager.

SECTION IV

INSTRUCTIONAL DELIVERY SYSTEMS

This section defines key terms in instructional delivery, summarizes major categories of instructional media, provides a brief analysis of selected media/delivery systems, and identifies trends in media development. In this report the term "media" will refer to the means for presenting instructional material to learners; for example, books, audiotapes, and filmstrips (see CNET Instruction 1500.12). The term "instructional delivery system" will refer to all of the elements with which the student must interact during the learning process to achieve instructional goals. The structure of this delivery system determines to a major extent the organization and presentation of information pertinent to training. In other words, an instructional delivery system is composed of a student, a method (or instructional strategy), and some form of media. One of the simplest instructional delivery systems might consist of a student and printed instructional materials, while one of the most complex might combine the student with an interactive adaptive CAI system.

Factors that must be considered in selecting media for the instructional delivery system should include the nature of the tasks, learning strategies, media types available, costs of alternative media mixes, state of development of proposed media approaches, and resources required for courseware development. TAEG's Training Effectiveness and Cost Effectiveness Prediction (TECEP) technique (Braby, 1975) is a procedure for choosing instructional delivery systems. It is useful in defining strategies for meeting training objectives, choosing instructional delivery systems for carrying out these strategies, and identifying the relative cost of the alternatives. However, experience with the TECEP technique has shown that choosing an optimum instructional delivery system for military training objectives is a subtle and complex decision making task that cannot be completely proceduralized. Furthermore, users of the TECEP technique must possess expert knowledge of media. The use of TECEP, however, should result in choosing the most cost-effective instructional delivery system.

CATEGORIES OF INSTRUCTIONAL MEDIA

Braby (1975, table 16) lists a "Media Pool" of 89 types of instructional media organized into seven categories. These categories are print material, audio-only systems, visual-only systems, audio-visual systems, CAI/CMI, simulated and operational systems, and special or nonstandard items. They are the major forms of instructional media being used or being considered for use in military training systems. Examples from each category are shown in table 2. Another categorization of instructional media is shown in table 3.

As a matter of interest, table 4 is included to show how 42 Army instructional media were grouped into 12 "families" (Silver, Bennick, Butler, and Benesch, 1978).

Videodisc and 2-D interactive computer graphic display systems have a high potential for innovative application in training. They also have a great deal of power in information transfer technology as well as possessing the possibility for increased achievement and transfer of training. These systems will be discussed in more detail in later sections of this report.

STATE-OF-THE-ART OF INSTRUCTIONAL DELIVERY SYSTEMS

The following paragraphs discuss available media in terms of their capability to improve instructional efficiency.

To effectively design an instructional system, the training system designer must know the capabilities and limitations of various media and their related costs. A voluminous and detailed report by Rhode, Esseff, Pusin, Quirk, and Shulik (1970) has assessed the available conventional media in terms of their instructional flexibility, support requirements, and initial and operational costs. The reader is referred to this report for detailed information on specific conventional media. However, several new learning media are deserving of some special attention because of their high potential in various aspects of the delivery of instruction.

TABLE 2. CATEGORIES OF INSTRUCTIONAL MEDIA (After Braby, 1975)

Print Materials:	books, self-scoring exercises, programmed text, study card sets
Audio-Only Systems:	audio tape system, dial access information retrieval system, language laboratory
Visual-Only Systems:	microform, panels, mockup, slide projector system, teaching machine
Audio-Visual Systems:	carrel, motion picture, teaching machines, television (closed circuit, videodisc and video tape systems)
CAI/CMI:	PLATO IV, TICCIT
Simulated and Operational Systems:	on-line and off-line computer simulations, logic trainers, operational equipment synthetically stimulated, simulators
Special and Non-standard Items:	automatic raters, dry carrel, classroom

TABLE 3. CATEGORIES OF INSTRUCTIONAL MEDIA (After Logan, 1977)

ETV	Radio	Programmed Text	CAI/CMI	Audio-Visual	Lecture
television video video tape		PI programmed text	computer-based systems	audio audio tape audio recordings audio-visual films filmstrip motion pictures multicolor visual slide still pictures/ graphs tape/slide transparencies visual	

TABLE 4. CATEGORIES OF ARMY INSTRUCTIONAL MEDIA
(After Silver, et al., 1978)

Job Materials

- Field Manuals (FMs)
- Technical Manuals (TMs)
- ITDT Technical Manuals

Printed Materials

- TEC Print
- Correspondence Courses

Training/Combat Literature

- Soldier's Manual/Job Book
- Skill Qualification Tests (SQT)
- Army Training and Evaluation Program (ARTEP)

Instructor with Standard Aids

- Class Packets
- Charts/Display Boards
- Overhead/Transparencies
- Models/Mockups

Audio-Only

- TEC Audio-Only
- Language Labs (GEL)

Audio-Visual

- TEC Audio/Visual (BESELER CUE/SEE)
- Slides/Sound Slides
- Army Training Films

Television/Video Recording

- Classroom Closed-Circuit Television (CCTV)
- Television Trainer (TVT)
- Video-Disc

Computer-Assisted/Managed Instruction (CAI/CMI)

- Remote-Access PLANIT
- PLATO IV/TUTOR
- ABASCUS Computerized Training System (CTS)

TABLE 4. CATEGORIES OF ARMY INSTRUCTIONAL MEDIA (continued)
(After Silver, et al., 1978)

Embedded Training (ET)

- Operational TACFIRE PLANIT
- TACFIRE Training System (TTS)
- TACFIRE Subsystem Team Training (TSTT)

Training Devices/Simulators

- Sand Table
- Fire Control Simulator BT-33
- Observed Fire Trainer (OFT)
- Artillery Direct Fire Trainer (ADFT)
- M-31 Field Artillery Trainer

Tactical Engagement Simulations (TES)

- SCOPES
- REALTRAIN (Exercise for Combined Arms Elements)
- MILES

Command/Staff Battle Simulations

- Tactical Exercise Without Troops (TEWTS)
- CPX Simulation Facility
- CAMMS (Computer Assisted Map Maneuver System)
- Combined Arms Tactical Training Simulator (CATTS)
- FIREFIGHT
- DUNN KEMPF
- PEGASUS
- First Battle

The current typical Navy delivery system is based primarily on print media moderated and managed by instructors (plus some use of conventional audiovisual media). This approach appears to have reached its limit of applications effectiveness. Not only are marginal efficiency improvements very small but usage is mismatched to the current training need (Bunderson, 1979a).

Just as conventional audiovisual media have been integrated into the instructional system by matching them and their specific advantages with the objectives of training, it is now essential to accomplish this for the newer media; e.g., current CAI systems and the other more sophisticated audio-visual media such as videodiscs. Their successful use requires analysis of their strengths and limitations through continuing research. For example, after 20 years of CAI system research it has been established that the primary benefit of these systems is derived from their capability for individualizing instruction. It is capable of adjusting instruction to meet student performance. For the current status of CAI, CMI, IMI, and PI, see Orlansky and String (1979) and Zajkowski, et al. (1979). Representative of the data to be found in these reports are tables 5 and 6, reproduced here to show the effectiveness of CAI and the extent to which it is being used operationally in Navy training. The roots of computer applications for the 1980's exist now, and there is not much likelihood that new design concepts will change how they are applied. Changes will most likely be limited to scale of use and in who will be using them (Office of Technology Assessment, 1979).

Two relatively new forms of instructional media have great potential for future instructional delivery systems, namely, 2-D interactive computer graphic display systems and videodisc. 2-D interactive computer graphic displays probably have more potential for wide application during the 1985 to 1995 time frame than any other CBID medium. This delivery mode can provide visual 2-D simulations with keyboard, light pen, sonic pen, photo sensing or touch panel student interactive capability. This interactive feature can be used in combination with direct input 3-D training components and other peripheral equipment for a fully integrated training system capability.

TABLE 5. SUMMARY OF FINDINGS ON CAI AND CMI, COMPARED TO CONVENTIONAL INSTRUCTION

Measure	Finding (Compared to Conventional Instruction)			Comments
	CAI		CMI	
Student Achievement	Some or more		Same	Performance measured only at school. Relation between performance at school and on the job not demonstrated. Observed differences not of practical importance.
Course Completion Time	No. of Comparisons	40	8	CMI: Most time savings maintained or increased with extended use.
	Time saved (Median)	29%	44%	
	Range	-31 to 89%	12 to 69%	
	No. of Comparisons	5	7	Computer-support saves little time beyond that of individualized instruction.
	Time saved Individualized Instruction	64%	51%	
	CAI	69%	CMI 51%	
Student Attrition	About the same		Slight increase may occur	CAI: very limited data CMI: possible decline in student quality
Student Attitudes	Favorable		Favorable	
Instructor Attitudes	Unfavorable		Unfavorable	Very limited data. Little attention given to instructors.
Cost	Less, due to student time savings		Less, due to student time savings	Data limited and incomplete.
Cost-effectiveness				Not known because cost data are limited and incomplete.

Source: Orlansky and String (1979)

TABLE 6. COMPUTER-AIDED INSTRUCTIONAL PROGRAMS PLANNED/IN PLACE IN NAVY TRAINING

CAI Identification	Training Use	Number of Students Stations	Locations	Remarks
TICCIT (MITRE/Hazeltine)	S-3A	Undetermined	North Island Cecil Field	In Use
EC-2/3 (Educational Computer Corporation's 2- and 3-dimensional panels with CRT)	AE	91	Memphis	14 systems under contract
	A5	103	Memphis	8 systems
	Marine	100	Camp Pendleton	27 systems
	Marine	60	Twentynine Palms	200 additional stations
	NAVAIR	Undetermined	Undetermined	
GETS (General Electric, computerized, self-contained, interactive training console)	TRIDENT (strategic Weapons Training)	15	Bangor	
	TRIDENT (Engineering Operations Training)	12	Bangor	
Device 20S17	OS "A" School	60	Undetermined	NTDS Training FY 84 Implementation
CT(O) CAI System	CT "A" School	15	Undetermined	Basic Communications and CT message handling
Not Designated	F-18	Undetermined	Undetermined	Planned for Future
Device 10H1	EW Operations and Maintenance	60-70	Corry Field	300 Learning Carrels will be under CMI

Source: Zajkowski et al. (1979)

Because of the computer dynamic capability for changing graphic display parameters (e.g., voltage or resistance values in electronics training), performance-based training will become possible. This is currently being accomplished very effectively on such systems as TICCIT, PLATO, and GETS, but the cost is still too high to justify wide scale application. However, the success of these systems along with projections of decreasing costs, makes this type of delivery very promising for future applications. Performance-based training and testing appears to be a major design goal for future training systems.

Videodisc is considered a revolutionary development in training technology because of its mass information storage capabilities and the flexibility in media materials which can be stored. It can store all displays that are now delivered on any audiovisual medium, such as color slides, super 8 mm film, videotape, or motion picture. The 108,000 video pages of a single disc can be used to deliver information in a small fraction of the space required by print documentation. It integrates the features of several different media into one simple storage and retrieval system. However, the authoring and production of one single master videotape of such materials prior to making master videodiscs also combines the problems of these media (Bunderson and Campbell, 1979).

Bunderson, Jarvis, and Mendenhall (1979) studied the implications for the videodisc authoring process of the following eight areas: the delivery system used (manually controlled, microprocessor controlled, computer controlled with either a CAI or TV display); media selection during ISD; instructional strategies; author mock-up and simulation prior to premastering; premastering; mastering and replication; composition of videodisc authoring team; and evaluation. These researchers concluded that although optical videodisc technology and its associated authoring technologies can be expected to be undergoing change during the next few years, videodisc has significant potential as a new media delivery system alternative for the Navy. However, they recommend that the Navy should not plan to use videodiscs in the immediate future but that the Naval Education and Training Command (NAVEDTRACOM) should track the development of the field. They further recommended that the

Navy should conduct R&D involving the development and mastering of a series of videodisc strategies on promising delivery system alternatives.

It is interesting to note that Fox (1980) believes that only limited research is needed. He believes it is possible to demonstrate new approaches for instructional management and delivery systems by applying state-of-the-art instructional technology in existing classroom settings. Fox (1979) has developed a microprocessor-driven Visual Image Controlled (Vis. I. Con) projector. His stand-alone instruction delivery system presents instructional materials on a functionally equivalent basis to that which can be accomplished on a video system. When the instructional program is validated on the Vis. I. Con, it can be transferred to a videodisc, which can be controlled by a microprocessor. This microprocessor can then function as a master controller for both instructional management and instructional delivery. Fox has seen no serious problems associated with current videodisc applications and believes it is now ready for use as an operational component of new instructional systems.

TRENDS

"Anything in the market place in 1988 is already in the laboratory in 1978" (Fields, 1979). The "building blocks" are believed to be known. What will be done in the future is a combining of the "blocks" into systems and applications.

According to the Office of Technology Assessment (1979), "the roots of most new computer applications in the 1980's exist now, and there is not much likelihood that a new concept of computer design will change the way we use them. Changes will be in scale of use and in who will be using them."

Bunderson (1979b) states that it is not possible for DOD to maintain conventional methods oriented around stand-up instructors and printed materials since training budgets are being cut every year. New courseware forms and new delivery systems must emerge. These new systems will be dependent on the widespread distribution of computer based delivery systems.

In the early 1980's small personal computers with limited memory will be available to provide answer analysis and feedback, prompting help, and diagnostics. The videodisc will be used increasingly as a medium for distribution of instruction. It will become competitive with other delivery systems such as audiocassettes, videocassettes, floppy discs, and printed pages. Print and audiovisual media will be transferred onto videodiscs and microcomputer-based systems. It will be cost effective to transfer existing courseware products that have been validated and are widely used to a single audiovisual delivery system such as a videodisc player.

The cost of microprocessor and memory module components which provide the computer capability for graphic display systems will continue to decrease in price for the next decade. Consequently, large scale application of 2-D interactive computer graphic display systems will be limited primarily by software development cost. Even in this relatively high cost area, many software advances are being made for entering and storing graphic information with low cost direct input devices. It is probable, that within 10 years, computer storage of graphic information will be the lowest cost option available for storing training-related visual information.

CAI will become more common as computer-based delivery systems become more widely used. The trend will be away from linear or fixed variety media which just present information. The trend will be to provide interactions between the trainee and media.

In addition, intelligent courseware, or intelligent CAI (ICAI) will increase rapidly. Strategies such as the following will be used: simulation of a performance environment (e.g., troubleshooting a circuit), diagnostic model of the trainee's status (e.g., discrepancies in procedural knowledge), prescriptive model for tutoring a trainee (e.g., giving hints for troubleshooting) (Bunderson, 1979b).

In the late 1980's and beyond, total distributed instructional delivery systems will be available. The system will be stand-alone with intelligent terminals. The learning station will have the storage and display character-

istics of videodiscs so all audiovisual courseware will be displayed by a single medium. CAI will be the preferred mode for providing training with feedback at a job site or on-the-job training, which, according to Scanland (1978), will increase due to the severe reductions in EDTRACOM resources.

At some duty stations, instructors may not be available, whereas in schoolhouses they will still be essential, though their roles will change. They will function in ways computerized systems cannot; e.g., providing models of the kind of sailor desired, stimulating enthusiasm and motivation, diagnosing problems not included in the computerized system, and coordinating tasks that integrate skills learned with the computer.

SECTION V

INSTRUCTIONAL MANAGEMENT ALTERNATIVES

This section describes instructional management alternatives which are deemed to be viable in the 1985-1995 time frame and provides an initial assessment of key management and economic characteristics for each. Two general categories of instructional management have been identified; namely, Instructor Based Instructional Management (IBIM) and Computer Based Instructional Management (CBIM). Each of these major categories can be further refined into subcategories by the inclusion of various combinations of the features of (1) centralized processing and data base control vs. decentralized processing and data base control and (2) the use of existing technology vs. new technology (state-of-the-art hardware and software). The eight possible combinations of these features are shown in table 7. However, only four of these eight are considered viable in the 1985-1995 time frame. These are:

1. Instructor Based Instructional Management (IBIM)--descriptive of traditional Navy instruction.

2. Centralized CBIM using existing technology--descriptive of the existing Navy CMI system.

3. Decentralized CBIM using existing technology--descriptive of the Navy's VTS and ATSS and the Air Force's AIS.

4. Decentralized CBIM using new technology. This is a reasonable description for a 1985 to 1995 system which would most likely be developed under an RDT&E program.

Each alternative identified in table 7 should be considered to represent a class of alternatives. The addition of some form of CBIA, CBIS, and CBID to each of these major classes is required to define a specific computer based training application. It is the latter completely specified system that will provide the basis for economic comparisons of various systems. Until such

TABLE 7. INSTRUCTIONAL MANAGEMENT ALTERNATIVES

INSTRUCTIONAL MANAGEMENT METHOD	EXISTING TECHNOLOGY		NEW TECHNOLOGY	
	CENTRALIZED	DECENTRALIZED	CENTRALIZED	DECENTRALIZED
IBIM	X	CURRENT IMI	X	X
CBIM	CURRENT CMI	ATSS TYPE SYSTEM	X	NEW DEVELOPMENT (RDT&E)

NOTES:

IBIM - Instructor Based Instructional Management
CBIM - Computer Based Instructional Management

[ ] - Viable Alternative

X - Nonviable Alternative

complete specifications are developed only the most rudimentary assessment of the four major classes of alternatives is possible.

Table 8 serves to identify system features and to summarize the outcome of an initial assessment of each of the four classes of alternatives based on these features. Each of the evaluative entries in the cells of the table represents a consensus of the study team based on data collected during the study. The data for alternatives 1 and 2 constitute an assessment of current capability while the data for alternatives 3 and 4 constitute predictions of the system capabilities.

Note that the major characteristics are divided into two major categories--management and economic. In the former category all management characteristics are considered to be essential in the 1985 to 1995 framework and therefore should serve as the basis for a comparative analysis. In the economic characteristics, investment and operating costs, which form the basis for life cycle cost, combined with training effectiveness provide an estimate of life cycle efficiency. These are the primary economic characteristics which form a basis for a comparative analysis. Expansion cost and efficiency refer to increasing the system capability beyond present or designed capabilities.

TABLE 8. CHARACTERISTICS OF ALTERNATIVES

ALTERNATIVE	CHARACTERISTICS											
	MANAGEMENT						ECONOMIC					
	Global Info Accessibility	Objectives and Test Item Data Bank	Resource Management Control System	Student Scheduling System	Reporting System	Management Control System	Investment Cost	Operating Cost	Training Effectiveness	Life Cycle Efficiency	Expansion Cost	Expansion Efficiency
Decentralized IBIM (IMI)	1	2	2	2	2	3	low	medium	low	medium	medium	medium
Centralized CBIM (existing technolgy)	3	4	2	4	3	3	low	medium	medium	high	high	low
Decentralized CBIM (existing technology)	4	4	4	4	4	4	medium	medium	medium	high	medium	high
Decentralized CBIM (new technology)	5	5	5	5	5	5	high	medium	high	medium	medium	high

5 - High
4 - Above Average
3 - Average
2 - Below Average
1 - Low

SECTION VI

RECOMMENDATIONS IN SUPPORT OF 1985 TO 1995 CBI SYSTEM DEVELOPMENT

Recommendations for support of CBI system development are presented below. They are based on study findings and assume that a new distributed computer system approach will be recognized as the most viable for future applications.

1. Establish a CNET staff management group with single-point authority and responsibility for all computer based instructional programs.

2. Establish a management and economic analysis committee with membership from CNET, TAEG, and functionals to develop analysis procedures, review proposals, and insure valid economic assessment of all proposed CBI applications. This committee should be supportive of the CBI staff management group yet independent for purposes of management and economic analysis.

3. Conduct an economic analysis to assess life-cycle cost-benefit for each of the four CBI alternatives proposed.

4. Determine the viable computer network architectural designs for distributed processing, distributed data base, communications protocol, and network management for proposed systems.

5. Prepare an Operational Requirement (OR) to identify viable strategies for integrating computer based instructional delivery systems into existing Navy training programs during the 1985 to 1995 time frame.

6. Prepare an OR to determine the types of software development programs needed to provide the necessary software support for Navy CBI applications during the 1985 to 1995 time frame.

7. Determine life-cycle support requirements for large scale CBI applications during the 1985 to 1995 time frame.

8. Prepare a master plan for the continued utilization and support of the existing Navy CMI system during development and integration of the 1985 to 1995 time frame replacement system.

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APPENDIX A

CONSULTANTS CONTRIBUTING TO THIS STUDY

CONSULTANTS CONTRIBUTING TO THIS STUDY

Thomas Ansbro
Code N-5
TAEG Detachment Pensacola
Pensacola, FL 32508
PH: 904-452-4201

Gilbert Bergsman
Naval Training Equipment Center
Code N-433
Orlando, FL 32813
PH: 305-646-5613

Dr. Richard Braby
Training Analysis and Evaluation Group
Orlando, FL 32813
PH: 305-646-5673

George Buzinki
Management Information and
Instructional Systems Activity
Naval Air Station, Memphis
Millington, TN 38054
PH: 901-872-5720

Robert W. Camp
Naval Training Equipment Center
Code N-211
Orlando, FL 32813
PH: 305-646-5753

Col. A. J. Castellana
Marine Corps Liaison Office
Naval Training Equipment Center
Orlando, FL 32813
PH: 305-646-4124

Dwain Chambers
Computer Managed Instruction System
Chief of Naval Technical Training
Code 824
Naval Air Station, Memphis
Millington, TN 38054
PH: 901-872-5375

Charles Clements
Data Systems Division
Ft. Gordon, GA 30905
PH: 404-791-3832

James M. Corey
Training Analysis and Evaluation Group
Orlando, FL 32813
PH: 305-646-4367

Gordon A. Crawford
Activity ADP Support Systems
Code 821
Chief of Naval Technical Training
Naval Air Station, Memphis
Millington, TN 38054
PH: 901-872-5375

Dr. David Daly
Naval Training Equipment Center
Code N-82
Orlando, FL 32813
PH: 305-646-4615

LCDR John A. Dollard
Navy Personnel Research and
Development Center
San Diego, CA 92152
PH: 714-225-7122

Stephen E. Doyle
Office of Technology Assessment
Congress of the United States
Washington, DC 20510
PH: 202-224-1448

Dr. Edwin P. Durall
Control Data Corporation
2101 L St. NW
Washington, DC 20037
PH: 202-789-6461

Raymond G. Fox
Learning Technology Institute
50 Culpeper Street
Warrenton, VA 22186
PH: 703-347-0055

CONSULTANTS CONTRIBUTING TO THIS STUDY (continued)

Eugene R. Hall
Training Analysis and Evaluation Group
Orlando, FL 32813
PH: 305-646-5673

Chester E. Harrison
IPD Analysis/Design/Development
Code N-914
Chief of Naval Education and Training
Pensacola, FL 32508
PH: 904-452-4507

John E. Hassen
IPD Curriculum Evaluations and Standards
Code N-93
Chief of Naval Education and Training
Pensacola, FL 32508
PH: 904-452-4507

Roy Herd
MILPERSIS Management Analyst
N-8212
Chief of Naval Technical Training
Naval Air Station, Memphis
Millington, TN 38054
PH: 901-872-5375

ETCM Jon H. Keeney
Force Master Chief
Chief of Naval Education and Training
Pensacola, FL 32508
PH: 904-452-3418

John W. Lang
IPD Analysis/Design/Development
Code N-9141
Chief of Naval Education and Training
Pensacola, FL 32508
PH: 904-452-4507

Manual B. Lopez
Naval Air Systems Command Headquarters
Code 4132
Washington, DC 20360
PH: 202-692-0981

Dr. L. R. MacKeraghan
Training Analysis and Evaluation Group
Orlando, FL 32813
PH: 305-646-4367

CAPT Alan F. Martin
Assistant Chief of Staff for Administration and Management Services
Code N-7
Pensacola, FL 32508
PH: 904-452-3345

Dr. James McMichael
Navy Personnel Research and Development Center
San Diego, CA 92152
PH: 714-225-7122

Morris G. Middleton
Training Analysis and Evaluation Group
Orlando, FL 32813
PH: 305-646-5198

Dr. William Mitzel
TRIDENT Training Facility, Bangor
Bremerton, WA 98315

Dr. William Montague
Navy Personnel Research and Development Center
San Diego, CA 92152
PH: 714-225-7121

Harry Musselwhite
Data Systems Division
Ft. Gordon, GA 30905
PH: 404-791-3832

Dr. Harold F. O'Neil, Jr.
Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333
PH: 202-274-8917

William O. Ottendorfer
Education ADP System (Code N-722)
Chief of Naval Education and Training
Pensacola, FL 32508
PH: 904-452-4104

CONSULTANTS CONTRIBUTING TO THIS STUDY (continued)

Ted E. Pearson
Naval Training Equipment Center
Code N-232
Orlando, FL 32813
PH: 305-646-4525

Dr. Henry Pennypacker
Department of Psychology
University of Florida
Gainesville, FL 32611
PH: 904-392-0694

John H. Pinning
Chief of Naval Education and Training
Code N51
Pensacola, FL 32508
PH: 904-452-4201

William A. Platt
Naval Training Equipment Center
N-241
Orlando, FL 32813
PH: 305-646-4451

Dr. William C. Rankin
Training Analysis and Evaluation Group
Orlando, FL 32813
PH: 305-646-5673

Dr. Joseph V. J. Ravenis II
Cubic Corporation
9233 Balboa Avenue
San Diego, CA 92123
PH: 714-277-6780

Donald K. Roadman
ADP AIS Management (Code N-724)
Chief of Naval Education and Training
Pensacola, FL 32508
PH: 904-452-4101

Phyllis Salop
Chief of Naval Technical Training
Code 8241
Naval Air Station, Memphis
Millington, TN 38054
PH: 901-872-5375

Susan E. Savage
Control Data Corporation
6003 Executive Boulevard
Rockville, MD 20852
PH: 301-468-8297

Dr. F. Worth Scanland
Assistant Chief of Staff for Research
and Instructional Systems Development
Code N-5
Chief of Naval Education and Training
Pensacola, FL 32508
PH: 904-452-4201

Edward H. Scheye
Instructional Delivery Systems Division
Code N-526
Chief of Naval Education and Training
Pensacola, FL 32508
PH: 904-452-4201

Charles S. Sharrocks, Jr.
Data-Design Laboratories
7925 Center Avenue
Cucamonga, CA 91730
PH: 714-987-2511

James M. Smith
DELTAK, Inc.
1843 State Road 434
Longwood, FL 32750
PH: 305-339-2233

Linda Smith
Assistant for Management Information
Systems
Chief of Naval Operations (OP-16M)
Washington, DC 20350
PH: 202-694-5534

Shirley C. Smith
Research for Better Schools, Inc.
444 N. 3rd Street
Philadelphia, PA 19123
PH: 215-574-9300

CONSULTANTS CONTRIBUTING TO THIS STUDY (continued)

Robert L. Stephens
Chief, Data Systems Division
Ft. Gordon, GA 30905
PH: 404-791-3014

Dr. Joanne Stolte
Research for Better Schools, Inc.
444 N. 3rd Street
Philadelphia, PA 19123
PH: 215-574-9300

W. B. Stubbs
Training Analysis and Evaluation Group
Orlando, FL 32813
PH: 305-646-4367

C. F. Summer, P.E.
Computer Systems Laboratory, N-74
Naval Training Equipment Center
Orlando, FL 32813
PH: 305-646-4437

B. E. Thompson
Instructional Program Development
Operations (Code N-91)
Chief of Naval Education and Training
Pensacola, FL 32508
PH: 904-452-4507

Boake C. Thompson
Naval Training Equipment Center
Code N-241
Orlando, FL 32813
PH: 305-646-4451

Charles M. Tilly
Director, Management Information and
Instructional Systems Activity
Naval Air Station, Memphis
Millington, TN 38054
PH: 901-872-5980

William H. Timby
SAI Corporation
2801 Camino Del Rio South
San Diego, CA 92108
PH: 714-293-7500

Dr. Donald Van Kekerix
Navy Personnel Research and
Development Center
San Diego, CA 92152
PH: 714-225-7121

Dr. Nicholas Van Matre
Navy Personnel Research and Development
Center
San Diego, CA 92152
PH: 714-225-7122

W. Scott Wheeler
Naval Training Equipment Center
Code N-241
Orlando, FL 32813
PH: 305-646-4451

John White
Data Systems Division
Ft. Gordon, GA 30905
PH: AV 780-3832

CDR Richard Woodley
Management Systems (Code N-71)
Chief of Naval Education and Training
Pensacola, FL 32508
PH: 904-452-3248

CAPT. J. E. Woolam
Assistant Chief of Staff for Centralized
Instructional Program Development
Code N-9
Chief of Naval Education and Training
Pensacola, FL 32508
PH: 904-452-4507

Dr. Joseph Yasutake
Instructional Technology Branch
USAF Human Resources Laboratory
Lowry AFB, CO 80230
PH: 303-394-4388

Dr. M. Michael Zajkowski
Training Analysis and Evaluation Group
Orlando, FL 32813
PH: 305-646-5198

APPENDIX B

MAJOR CATEGORIES, SUBCATEGORIES AND FUNCTIONS OF CBI

MAJOR CATEGORIES, SUBCATEGORIES AND FUNCTIONS OF CBI

COMPUTER BASED INSTRUCTIONAL MANAGEMENT (CBIM)

1. Student Scheduling/Sequencing. This functional category provides for the control and tracking of all student activity beginning with registration and ending with course completion or precompletion termination. It utilizes information from student records, entry level test results, course organization and sequencing strategy, progress and diagnostic test results, administrative inputs, student location control reports, time to complete estimates, and time in process measures as assignment alternatives are continuously assessed for optimal scheduling. Student assignment, scheduling, and tracking functions include:

a. Student registration provides for the initialization of the student into the training system. It consists of entering student information into the training system data files to allow for the maintenance of student assignment, progress, and history records. It also provides student profile information for assessment of viable training track alternatives and for estimates of course completion.

b. Student assignment and scheduling includes the functions required to analyze current student status and to generate student learning guides. Student progress indices, course organization and mapping, learning resource availability, and progress test response patterns are analyzed to provide a basis for generating these guides which specify a training path. This process relates student assignment options to student status and learning resource availability and then selects a training path which best satisfies the training objectives.

c. Student tracking enters the scheduled activity into the student scheduling and tracking program as an in-process activity when a training path is selected. This activity is then tracked and is utilized as a basis for measuring student progress.

2. Module-Lesson Data Bank. The training system module and lesson data bank would consist of a dedicated storage area within the training center computerized common data base which would contain descriptive and identification information for learning modules and lessons within the training center course organization hierarchy. In addition, it would contain a description and identification of the training materials, training objectives, progress and diagnostic test items and audit vectors for instructional accountability. The functions within this category include:

a. Training objectives files would fully describe and identify the training objectives related to course modules and lessons. These training objectives would normally be developed during a front end analysis for the Instructional Program Development case. However, objectives could also be developed for existing programs of instruction through the analysis of course content.

b. Training material description and identification records would be developed for the training material used in support of module or lesson level instruction. This training material identification system would be used for student guide generation related to specific module and lesson assignment.

c. Test item files would be grouped by module and lesson for measuring student achievement. These testing materials would also include pre, post, and diagnostic test items.

d. Course audit and accountability includes all of the functions required to assure the integrity of learning objectives as they relate to learning materials and test items.

3. Testing. The training system testing functional category would include methods for accessing all test items to be presented during the testing process. Test items would relate to the learning material presented and would follow predefined testing strategies. Item generation, response

scoring and storage, item analysis, diagnostic test item generation, randomization of test item sequences, and test security would be included in this category.

a. Test generation would be possible for any module or lesson within a course of instruction. Selection and sequencing of test items would be generated in accordance with course hierarchy mapping, learning module identification, student achievement, and diagnostic test results. Tests would be generated in accordance with the applicable testing strategy. Uniqueness resulting from randomization and customization would also provide a basis for developing the test security system.

b. Response scoring would apply to the instructor scoring case or the machine scoring case in which a test key is used as a basis for scoring. However, the computerized case would allow for a decode of test item randomzation and would facilitate an analysis of test response patterns. Consequently, greater prescriptive guidance flexibility would be possible for the computerized case.

c. Training path selection and prescriptive guidance should be possible for any type of path selection strategy used by the instructional designer. This function is difficult and time consuming to implement for the instructor management case but it is relatively easy to implement for the computerized case.

d. Test response storage should provide for short term machine readable storage of all student test responses. This test response data bank should be converted to long term machine readable storage when students complete training. This data can then serve as a basis for test item analysis and course effectiveness evaluation.

COMPUTER BASED INSTRUCTIONAL ADMINISTRATION (CBIA)

1. Management and Administration. This category includes all of the organizational functions required to administer instructional programs. It is intended to be the master management control category for all other functional categories. The functions within this category include the following:

a. School management function includes the planning, organization, and administration functions which support school operations.

b. Management policy and control includes all of the management control mechanisms for assuring compliance with management policy. It relates to the dissemination of management directives, to the communications of management information for control structure feedback, and to the measurement of management system effectiveness.

c. Personnel management consists of the data processing support transactions for the administrative control of staff and student personnel.

d. Computer systems management includes all of the organization and management functions required for the acquisition, operation, and maintenance of computer hardware and software. Although the computer operations function would properly be located within a computer group, all policy, standards, and management control procedures should be under the direction of a training directorate to assure compliance with training goals and objectives.

e. Course organization includes descriptors and identifiers for all modules and lessons within a course hierarchy.

f. Student record control includes all processes related to student record entries, information access, and training transactions.

g. Data control and communications supports policy making for information standards, integrity, and security. Although the data management system and the report generation system components would be independently operable, data control should remain within the training system management organization. Administrative information should be communicated from a single data communications location within a school or training center to any external organization requiring the information. Student data, course data, predictive data, and effectiveness data could be used as a basis for systems analysis, student assignment, and management control.

2. Report Generation. This functional category includes all of the programs required to access, convert, organize, and format data and to generate data output for display or hard copy. It would also include the generation of unique symbols or graphic displays required for special use applications. The following reports are examples of outputs from this subsystem:

a. training schedules
b. administrative reports
c. computer system status reports
d. configuration management reports
e. course/module/lesson evaluation reports
f. resource management reports
g. Instructional Program Development status reports
h. productivity/efficiency/cost reports
i. student learning guides
j. student progress reports

COMPUTER BASED INSTRUCTIONAL SUPPORT (CBIS)

1. Training Resource Management. This functional category relates to the management of training system resources and should include all personnel, facilities, equipment, software, and expendables required during execution of the training process. As a student transitions through a course of instruction, student station assignment, learning materials assign-

ment, and instructor consultation will require scheduling and control. Although this is currently accomplished in most Navy training settings by the instructional staff, there are many cases in which computer based systems perform these functions.

a. Training resource inventory control includes all of the functions required to identify, catalog, store, assign or issue, record, and control all physical training resources. Although personnel resources can be considered training resources, they are not included within the resource inventory control function because their control is included in the management and administration function. A similar situation exists for facilities and facilities support equipment. Although classrooms and student stations are scheduled by resource scheduling programs, facilities managment is not included as a training management function.

b. Training resource scheduling includes the functional activity related to allocating learning resources (such as student stations and learning materials) in such a way as to maximize the efficiency of resource utilization and minimize the student waiting time for resource assignment. Scheduling strategies should vary in accordance with course loading, resource availability, and student assignment options. Resource allocation records should be maintained for analysis and accountability purposes.

c. Training resource accountability functions include all of the activities relating to the monitoring of the status, utilization, and maintenance of resources. This function also includes record keeping and analysis of resource use to provide a basis for adjusting resource levels and modifying resource scheduling strategies.

2. Instructional Program Development Coordination. This functional category includes all of the activity required to maintain schedules for learning material development activity. The training material to be developed or under development will normally add to or replace existing training resources and consequently will require planning for integration into existing

instructional systems. The instructional management plan to be utilized in conjunction with the new and revised learning materials must also be incorporated into the management, administration, scheduling, and tracking systems.

a. Instructional program development requirements relates to needs assessment and requirements development. If the changed or new requirement results in development which will affect a training program, a tracking mechanism should be energized during the conceptual phases. In this way, the research, development, and implementation process will be coordinated with the integration of the new or revised training material into the existing training program and the necessary planning and programming lead time will be provided.

b. Program development schedule functions include the planning and scheduling activity which precedes development. These functions would be carried out in coordination with the development agent and should result in a single development schedule which is tracked by the developers, the implementers, the user, and the evaluator.

c. Program development tracking and reporting relates to the tracking activity which takes place during the devleopment and implementation process. It should be accompanied by information reporting to be used by instructional program development management and by instructional process management.

3. Configuration Management. Because training materials and computer programs are constantly in a state of change for the general case, a need exists to incorporate a configuration management system to track changes and configuration status. It is evident that training objectives must relate to training materials, while test items must relate to both. What is less evident but equally important is that the course scheduling and tracking programs and training resource allocation programs must also relate to training program objectives. As the process of developing training systems becomes more closely aligned with the development of the more complex weapons systems to which they must necessarily relate, a requirement to implement similar

configuration control systems will become evident. To design, develop, and implement some of today's more sophisticated computer based training systems without incorporating a configuration management system would be to assure future degradation and potential system failure. Configuration management techniques have been used effectively for many years on all types of computer based systems and it is not envisioned that the application of these techniques to computer based training systems would cause any significant problems. Some of the functions which should be subject to configuration control include:

a. course organization
b. facilities and training stations
c. training equipment and devices
d. module/lesson objectives and test items
e. learning materials
f. computer hardware
g. computer software.

Configuration management would provide the needed change control, status accounting, and system audit capabilities for continuously evolving training applications. It would allow for operational efficiency under conditions of constant change, a characteristic which appears essential in today's dynamic environment.

4. Computer Support. For those functional categories within the instructional management system which are partially or fully computerized there will be a need to manage the computerization process. Both hardware and software systems require diagnostic programs for preventative and corrective maintenance. A full range of maintenance and operation support documentation should be available for life cycle support. This documentation should include such typical information as logic diagrams, system block diagrams, operating system descriptions, application programs design and interface specifications, data base management organization, and data communications requirements and specifications. All of this support documentation should be controlled within the configuration management functional category. An audit capability should also exist for validating the performance of any hardware or software subsystem.

a. Computer hardware and software organization should include block diagrams and functional descriptions for all hardware input, processing, storage and output subsystems, and the operating system and applications programs. Data base organization, data base access and communications protocol specifications should also be provided together with operating procedures for system use.

b. Data base organization and management documentation should describe file organization, data formats, data types, data conversion requirements, common data pool use, data access, data protection, and report generation interface. Memory mapping for local and shared data should also be provided for ease of integrating new programs or modifying existing programs. Although much of this information can only be displayed in formats requiring interpretation by computer specialists, an attempt should be made to describe all data organization in user language and functional block diagrams.

c. Program performance functional specifications include all documentation describing the functional capabilities of applications programs. These functional descriptions provide the basis for validating program performance and serve as the primary descriptive documents for establishing system design goals.

d. Interface specifications would maintain a current file for all intra-computer and inter-computer hardware and software interface specifications. This information would be available in the form of CRT display or hard copy output and would be maintained in accordance with configuration management standards.

e. Data communications protocol would maintain current files on all data communications standards. Communications test programs and network diagnostic programs would also be included for initialization and monitoring of network operations.

f. System operating procedures would provide CRT display, hard copy printout or operating manual description and identification of all system operating procedures. Prompting and menu selection in user terminology would be provided for ease of use by all operations personnel.

g. System maintenance support programs and documentation includes programming for all maintenance support activity. Maintenance procedures, diagnostics, references to maintenance documentation, tools and equipment listings, maintenance action record keeping, maintenance analysis reports, and other software and hardware maintenance related programs would provide a semi-automated maintenance support capability.

COMPUTER BASED INSTRUCTIONAL DELIVERY (CBID)

1. Conventional CAI
2. Computer Simulation
3. Computer Controlled Video
4. Computer Graphics.